Legacy Cove Project Note No. 3

Trace Metals in Edible Marine Species

Hawk Inlet, Admiralty Island, Alaska

Friends of Admiralty

SUMMARY

Clams, crab, shrimp, seaweed and many other ocean delicacies are revered traditional and personal use wild foods available to northern Southeast Alaskans from special habitats during specific tidal patterns throughout the year. Hawk Inlet off of Chatham Strait is just such a habitat. Government-directed monitoring of seafloor worms and mussels in Hawk Inlet has shown that metals from the Greens Creek Mine ore body are present in the Hawk Inlet foodweb. For this reason, we conducted a reconnaissance survey to explore whether heavy metals were also accumulating in seafood species or whether their habitats or populations had been affected by the industrial mine operating in uplands of the Admiralty Island National Marine Monument and adjacent seaways. To examine this question, cockles, clams, black seaweed, crab and shrimp were analyzed for eleven trace metals: arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), manganese (Mn), mercury (Hg), nickel (Ni), selenium (Se), silver (Ag) and zinc (Zn) from Hawk Inlet.

Results show that shrimp, crab, butter clams, cockles and blue mussels from Hawk Inlet have higher concentrations of As, Cd, Cr, Pb (except butter clams), Ni (except cockles) and Se than Alaska-wide seafood data for the same species. Most metals (As, Cd, Cr, Cu, Pb, Ni, Se, Ag, Zn) are higher in Hawk Inlet blue mussels than reported for the NOAA-directed, Alaska-wide environmental monitoring program called Mussel Watch. As, Cr, Cu, Pb, Ni and Se levels in Hawk Inlet blue mussels are two to five times higher in concentration in 2015 than levels reported as 1978, 1981 and 1984-1989 baseline levels measured prior to full operation of the industrial mine in the Hawk Inlet watershed.

Historical records document an abrupt increase in these metals in Hawk Inlet after the mine began operations, and the suite of metals in biota continues to reflect the composition of ore being extracted. Metal concentrations at levels observed in Hawk Inlet edible marine species are indicative of ecosystem degradation compared to pristine Alaska sites. Individual species are likely experiencing myriad sub-lethal physiological effects, including reproductive impairment, immunosuppression, reduced energy production capacity, abnormal larval development and neurological challenges. Elucidating the effect of these changes on the Hawk Inlet foodweb will require further analysis of pre-mining baseline data and field sampling to evaluate trends in bioaccumulation of heavy metals and their impacts at baseline study sites.

INTRODUCTION

Alaskans from the Native Community of Angoon, as well as residents of Hoonah, Tenakee, Juneau and Douglas harvest several subsistence, personal use, guided sport and commercial seafood species from Hawk Inlet. Proximity to town ports, natural protection from weather and the advent of a burgeoning visitor charter industry make Hawk Inlet fishery resources accessible to professional and casual harvesters. Closures of Stephens Passage and waters around Juneau to address shrimp resource declines in 2013 and similar species protection closures near towns has shifted effort to the Chatham Strait/Hawk Inlet area (ADFG 2013). During the summer of 2015, over 100 buoys from crab pots, shrimp pots and possibly groundfish longline gear were observed inside Hawk Inlet. Dozens of anglers flown in via floatplane and several clam diggers were also observed at the Greens Creek Delta intermittently (Ridgway, pers. obsvn.).

Historical subsistence harvest and present high fishing activity raised the question of whether the worm and bivalve 'indicator' species tested annually under Government auspices for heavy metals were reflective of the health of broader foodweb in Hawk Inlet, specifically harvested seafood species. Because Friends of Admiralty had funded a study of the Hawk Inlet ecosystem, data on edible species was summarized from the more comprehensive ecosystem study results.

BACKGROUND /Impetus for sampling

The language in the Alaska National Interest Lands Conservation Act (ANILCA) that authorizes Greens Creek mine to operate in Admiralty Island National Monument is very specific in setting a high standard of operation - stating that the milling and tailings will not cause irreparable harm to Admiralty Island National Monument. There is also specific direction that mining will maintain fish habitats (marine and fresh waters). There is also specific direction that protects subsistence uses. Every state and federal permit for this mine has determined that these standards are being met.Marine life protection in Hawk Inlet and sustaining populations, quality and access to wild foods in the Inlet are US Forest Service (USFS) priorities documented in every environmental assessment for the Greens Creek Mine project since its inception. The original Environmental Impact Statement for the Greens Creek Mine in the Admiralty Island National Marine Monument adjacent to Hawk Inlet reported that sport and subsistence foods taken from the area included salmon, halibut, flat fish, cod, king crab, Tanner crab, Dungeness crab, mussels, clams and shrimps (USFS 1982). Following several years of exploratory mining, researchers noted that "concentrations of mercury, zinc, silver and possibly cadmium are somewhat elevated, and in some cases exceed US EPA criteria for protection of aquatic life" (DEIS p 3-6, USFS 1982). Government officials also predicted that "If water treatment were continued in perpetuity, there would be negligible adverse effects to receiving surface water, groundwater or marine water." Further NEPA document predictions continued to indicate that "None of the alternatives have any impact on … heritage resources. The impacts of all alternatives on… marine water quality, … subsistence and recreation are negligible. The impacts of all alternatives are minor for … Essential Fish Habitat." (Executive Summary 2003 FEIS).

An Alaska National Interest Lands Conservation Act (ANILCA) Section 810 subsistence evaluation was conducted during the EIS process. It concluded that there will not be a significant possibility of a significant restriction on the abundance and distribution of, access to, or competition for subsistence resources in the project area (FEIS 1983 and FEIS 2003). To address the impact of commuting miners hunting and fishing on those resources, pro-active policies were implemented by the mine to minimize workers harvesting wild foods from the mine's environmental footprint and vicinity.

Wild foods harvested by rural Southeast Alaskans is estimated at 200 pounds per person per year, while Juneau residents harvest an estimated 22 pounds of wildfoods per person year, according to the Alaska Department of Fish and Game Subsistence Division 2012 surveys (ADFG 2012). In the case of Juneau, this amounts to an estimated total 715,553 pounds of wild harvested food (fish, mammals, marine invertebrates). Hawk Inlet is a popular harvest location among Juneau-Douglas residents who travel to the area by boat and floatplane. Juneauites, charter fishermen and transient visitors deploy shrimp pots, Dungeness pots, king crab pots throughout the inlet, as well as jig for halibut, fish for salmon, harvest clams and hunt deer, bear and birds in Hawk Inlet.

In the case of Angoon, their household use of just marine invertebrates and marine plants (seaweeds) is summarized in Table 1 for years up to 1988 and 2012 (ADFG 2012, USFWS 1988). In 2012, Angoon harvested an additional estimated 7,670 pounds of "miscellaneous marine invertebrates" (ADFG 2012).

With such extensive harvest of marine wildfoods by multiple sectors inside Hawk Inlet, quantitatively assessing changes to populations of targeted species is beyond the scope of the current reconnaissance work. However, evaluating health of marine resources using trace metal concentrations and implications for the Hawk Inlet foodweb could be contemplated by examining current and historical trends from laboratory data. Our approach was to extract data from 2015 samples and metal analysis, and contrast these values with reported Alaskan "natural" metal levels, Hawk inlet historical metal levels and data from other sites for comparison. Data on organic contaminants are reported elsewhere.

Species selected for analysis were based upon historic and current use by people, importance in the marine foodweb, availability in Hawk Inlet, and for purposes of comparison with other data sets. For example, although the seaweed *Fucus* is rarely consumed directly by Alaskans, some people eat young *Fucus* with herring roe attached, some Alaskans collect it for use in soups, and **many** Alaskans use *Fucus* to improve vegetable garden soil. Deer, bear, birds and marine snails directly consume *Fucus*, as do other invertebrates that also use it for habitat. Additionally, this species of seaweed is recognized as an effective biomonitor for metals in the ocean by scientists under the European Water Framework Directives and other research initiatives globally (Pratas et al 2000). Similarly, mussels may not be consumed directly by many SE Alaskans (due to risk of paralytic shellfish poisoning), but mussels were analyzed because they are an international standard biomonitoring species, are consumed widely in the marine foodweb, are accessible and abundant in Hawk Inlet, and are included in the suite of species analyzed for the baseline and annual bioassay sampling programs in Hawk Inlet.

METHODS

The FOA field team harvested clams, cockles, mussels and seaweed from throughout Hawk Inlet during the spring low tide series in mid-May, 2015. The minus tide lowest range was -2.13 to -3.38 feet during this period (NOAA Hawk Inlet Station 9452294). Shellfish were sorted by species at harvesting location, rinsed in seawater and allowed to soak separately in buckets in seawater from the site where they were collected for about 24 hours. Seaweed was also rinsed in seawater, squeezed to remove excess water and placed in new ziplock bags rinsed with double distilled, deionized water (DDDW). Harvest sites, times and weather were documented by handheld GPS and in field notebooks, respectively. Bivalves were shucked and meats removed and placed into laboratory-prepared 4-oz glass jars using metal free instruments prepared according to project protocols (alconox wash, 2x rinse with DDDW, etc.).

Shrimp and crab were received from sport fishermen fresh and whole, whereupon they were bagged, labelled and chilled on ice. In the metal free lab environment, shrimp muscle and crab muscle were separated from carapace and viscera. Meat only was retained for lab analysis. All specimens were shipped to Seattle ARI analytical laboratory via Goldstreak in COC sealed coolers with sufficient ice to maintain sample temperatures at or below 6 degrees Celsius. Chain of Custody documentation was maintained for all samples.

Tissues were prepared and analyzed by a certified commercial laboratory using US EPA certified methods for eleven trace metals. Tissue condition and quantity met or exceeded laboratory requirements for analysis. Tissues were prepared using US EPA Method 3050B (for all metals but mercury), and Method CLP-M was used for mercury. Tissues were analyzed using EPA Method 6010C for most metals, and Method 7471A was used for mercury. Data are reported in mg/kg wet weight. Analyses proceeded without incident, and met or exceeded the laboratory quality assurance program plan criteria, unless otherwise noted.



RESULTS

Imagery of some edible wildfood species harvested in Hawk Inlet in May 2015 are shown below.

Butter clams (*Saxidomus giganteus*) Pandalid shrimp Blue Mussels (*Mytilus trossulus*)



Cockles Intertidal bivalve habitat Blue Mussel clusters Helmet crab Black seaweed





Trace Metal Results and Comparison with Other Studies in Hawk Inlet and Elsewhere

Results of trace metal analyses and data from other sites, plus Hawk Inlet historical data are in Appendices in formal reports on the Legacy Cove project. In order to compare data measured as wet weight vs dry weight, calculations must be made to convert lab values to correct for the effect of seafood water content on concentration of metals. Trace metal concentrations measured for seafood quality are reported as "fresh", "raw", or wet weight. Data for examining environmental contaminants are typically reported in, and regulated by, metal concentration in dehydrated tissue so the moisture content is standardized. Fresh seafood such as fish, crab and clams contain from 73 to 84% water in the fresh condition (mussels can exceed 90% water content), thus trace metals in the tissue are diluted by that water content

(Martin *et al* 2000). Converting metal concentration data from wet weight to dry weight is essential to compare to data reported in dry weight, using the following formula (per Gerlach, ADEC 2015 and National Shellfisheries Assn 1980).

Dry weight concentration = (wet weight concentration/(100-%moisture)) x 100

Where conversions between wet and dry weight are made in this document for bivalve molluscs, the conservative value of 75% moisture is used for conversion calculations.

Seaweed: Black seaweed (*Porphyra* sp.) and rockweed (*Fucus* sp.) from Hawk Inlet contained detectable concentrations of most metals analyzed, and *Fucus* had higher concentrations of arsenic, cadmium and zinc. Neither *Porphyra* nor *Fucus* had detectable levels of lead (Pb), mercury (Hg), selenium (Se) or silver (Ag) at or above the level of quantification (these values are flagged with **U**) in the table below. Note that these values are reported as fresh weight, and seaweeds contain 73-90% water. Thus, the values are greatly diluted compared to values reported as dry weight.

Metal	As	Cd	Cr	Cu	Pb	Mn	Hg	Ni	Se	Ag	Zn
Porphyra	1.0	0.09	0.3	1.01	0.4 U	6.46	0.005 U	0.2	1 U	0.06 U	2.9
Fucus	5	0.295	0.25	0.65	0.4 U	6.09	0.005 U	0.9	1 U	0.06 U	4.85

Shrimp: Hawk Inlet shrimp tissue contained higher levels of cadmium, chromium, and nickel than the *maximum* levels reported by the Alaska Department of Conservation for Alaskan shrimp in the State's online status of seafood database (ADEC 2015). Arsenic was also elevated above the ADEC reported mean, but Hawk Inlet shrimp arsenic level was within the range for other shrimp tested in the State. Note that both Hawk Inlet and the Alaska reference include very small sample sizes.

Species	Site	As	Cd	Cr	Cu	Pb	Mn	Hg	Ni	Se	Ag	Zn
Side-Stripe Shrimp	Hawk Inlet n=1	**7**	**<u>0.13</u>**	**0.5**	11.9	0.4 U	2.65	0.032	**<u>0.3</u>**	1	0.47	15
ALASKA REF[1] Side-Striped Shrimp	ADEC n=3	1.5-21	0.031 0.025-0.037	0.01 0.01-0.01	---	0.015 ND-0.02	---	---	ND <0.02	---	---	---

Values are in mg/kg wet weight. Values in bold are above the Alaska ADEC reference average; bold and underlined values are above the maximum concentration reported by ADEC. Note that the ADEC REF data are from field samples and do not imply safe levels or standards for heavy metals in crab for human consumption.

Crab: Helmet crab were analyzed for metals, and concentrations are reported below as mg/kg fresh weight. For comparison, data from 131 Dungeness crab (a very closely related species) from across Alaska are reported from the State of Alaska ADEC Division of Epidemiology database; these values are also presented in fresh weight mg/kg. The ADEC online data has no measurements for manganese, silver or zinc levels in Dungeness crab.

Hawk Inlet Helmet crab had metals levels exceeding the maximum range reported for four of the eight metals shown in the comparison in the table below: Helmet crab concentrations of chromium, copper, lead, and selenium are higher than the maximum reported for all 131 Dungeness crab sampled Statewide. Cadmium and nickel in Helmet crab were higher than the average level reported for Dungeness crab statewide. Nickel in Hawk Inlet Helmet crab was 5x higher than the average for Dungeness crab, but within the range of levels found for Dungeness statewide. Helmet crab arsenic and mercury levels were below the average but in the range for arsenic and mercury reported by ADEC (ADEC 2015).

Species	Site	As	Cd	Cr	Cu	Pb	Mn	Hg	Ni	Se	Ag	Zn
Helmet Crab	Hawk Inlet 1	4	**1.07**	**<u>0.6</u>**	**<u>10.4</u>**	**<u>0.8</u>**	1.52	0.029	**0.5**	**<u>2</u>**	0.3	32.4
ALASKA REF Dungeness Crab	ADEC n=131	7.8 1.4-47	0.018-0.28 0-2.2	ND-0.03	8.5 7.1-9.9	0.052 ND-0.14	---	0.054 0.031-0.071	0.11 ND-0.70	0.61 0.44-0.91	--	--

Values are in mg/kg wet weight. Values in bold are above the Alaska ADEC reference average; bold and underlined values are above the maximum concentration reported by ADEC. Note that the ADEC REF data are from field samples and do not imply safe levels or standards for heavy metals in crab for human consumption.

Butter Clams, Cockles and Mussels: Results from analysis of metals in bivalves from Hawk Inlet are provided in Appendices in project reports. Highlights of these data are described here for butter clams, cockles and blue mussels.

<u>Butter Clams</u> (*Saxidomus giganteus*): Hawk Inlet butter clam tissue had higher arsenic, cadmium, chromium nickel and selenium than the average level for these metals reported by ADEC for butter clams in the statewide database. The ADEC database did not report on copper, manganese, mercury, silver or zinc levels in butter clams. Other clam species tested from Hawk Inlet (steamers, horse clam, pink neck and softshell) exhibited similar metal levels as reported here for butter clams in Hawk Inlet, and the Alaska reference metal range for other clam species was similar to the Alaska reference for butter clams (ADEC 2015).

Species	Site	As	Cd	Cr	Cu	Pb	Mn	Hg	Ni	Se	Ag	Zn
Butter Clam	Hawk Inlet	**7**	**0.29**	**<u>1</u>**	4.42	0.4 U	1.36	0.009	**0.7**	**<u>1</u>**	2.68	16.4
ALASKA REF Butter Clam	ADEC N=67	4.5 .94-16	0.14 0.028-0.61	0.39 0.26-0.9	---	0.062 0.05-0.23	---	---	0.62 0.19-1.9	0.18 0.12-0.23	--	--

Values are in mg/kg wet weight. Values in bold are above the Alaska ADEC reference average; bold and underlined values are above the maximum concentration reported by ADEC. Note that the ADEC REF data are from field samples and do not imply safe levels or standards for heavy metals in crab for human consumption.

<u>Cockles</u> (*Clinocardium* sp.): Arsenic, cadmium, chromium, lead and selenium concentrations in Hawk Inlet cockles exceeded average values for those metals reported by ADEC by about 3 to 5X, and exceeded maximum values reported by ADEC in every case. Nickel in Hawk Inlet was within the reported range for cockles statewide, and no data are available for comparison with copper, manganese, mercury silver and zinc at the time of this writing. All of these metals were above detection range.

Species	Site	As	Cd	Cr	Cu	Pb	Mn	Hg	Ni	Se	Ag	Zn
Cockle	HI n=3	**<u>3.33</u>**	**<u>0.23</u>**	**<u>0.90</u>**	3.04	**<u>0.93</u>**	2.23	0.01	0.77	**<u>2.33</u>**	0.22	14.9
ALASKA REF Cockle	ADEC n=11	0.69 0.52 - 0.84	0.054 0.023-0.11	0.26 0.07-0.72	---	0.09 0.03-0.18	---	---	0.84 0.22-1.6	0.22	---	---

Values are in mg/kg wet weight. Values in bold are above the Alaska ADEC reference average; bold and underlined values are above the maximum concentration reported by ADEC. Note that the ADEC REF data are from field samples and do not imply safe levels or standards for heavy metals in crab for human consumption.

<u>Blue Mussels</u> (*Mytilus trossulus*): Three sample results for mussels were averaged and are shown in the table below. For Hawk Inlet data, each sample was a whole tissue composite of 6 to 13 individual organisms at each sample site. Seven metals levels could be compared with the ADEC database. In each case, except mercury, Hawk Inlet mussels exceeded average levels reported for the 67 samples tested statewide (ADEC 2015). Chromium, lead, and selenium in Hawk Inlet mussels exceeded the maximum reported values in the ADEC database for seafood. Selenium and chromium were particularly high compared to the ADEC database, at 7 to 9 times the average reported from the ADEC mussel database.

Species	Site	As	Cd	Cr	Cu	Pb	Mn	Hg	Ni	Se	Ag	Zn
Mussel	HI n=3	**2.67**	**1.04**	**<u>1.23</u>**	8.36	**<u>0.87</u>**	3.05	0.01	**1.20**	**<u>1.67</u>**	0.06	20.73
ALASKA REF Mussel	ADEC ww n=67	1.0 0.35 - 2.9	0.92 0.11 - 10	0.14 ND-0.03	---	0.098 ND-0.57	---	0.018 * ND-0.053	0.23 0.06-2	0.25 0.24-0.25	---	---

Values are in mg/kg wet weight. Values in bold are above the Alaska ADEC reference average; bold and underlined values are above the maximum concentration reported by ADEC. Note that the ADEC REF data do not imply safe levels or standards for heavy metals in crab for human consumption. *N=23

Quality control analyses results for method blanks, laboratory duplicates, RPDs and matrix spikes are contained in Level I laboratory reporting documents and will be summarized in future Legacy Cove formal project reports.

DISCUSSION

Heavy metals occur in the natural environment and are both sequestered and eliminated by invertebrates depending upon their health needs, health status, and physiological capability to manage levels and forms of metals. Understanding heavy metal levels and effects in marine organisms is complex, and varies based on local geologic chemistry, as well as species, gender and age of the organism. Long term studies of heavy metals globally show that seafood can be contaminated to the point of being unhealthy to consume by both anthropogenic and natural metal sources. Shellfish species' reproduction, growth, genetics and population viability have been impaired or failed completely in metal-laden marine environments (Hornberger et al 2000; McGovern et al 2011; Paris et al 2015; Pratas et al 2000). Comparing concentrations of metals in marine organisms found in this study to other areas in Alaska and over time can provide some indication of the relative metal loading status and trends for edible marine species in Hawk Inlet.

Based upon direct comparisons of Hawk Inlet data to the ADEC Statewide seafood metals database, Hawk Inlet shrimp, crab and bivalves tested are consistently higher in arsenic, cadmium, chromium, selenium than the same Alaskan seafood type statewide. In some cases, nickel and lead exceed statewide average and maximum levels. For most species, there are no data for mercury, zinc, silver or copper in the ADEC database for comparison.

Another means to compare Hawk Inlet to Alaska statewide values for edible marine species is using the Alaska database within the Nationwide Bioeffects and Mussel Watch programs data portal (NOAA NS&T 2015). Only two shrimp datum are in the Alaska database, from the Bering Sea. Compared to these two samples, the Hawk Inlet shrimp analyzed are 4X higher in arsenic, lead and mercury and 2X higher in silver and selenium levels. Other metals are roughly equivalent to the NS&T values (NOAA NS&T 2015). Cockles and clams from Hawk Inlet are consistently higher in arsenic and selenium than the Alaskan NS&T values.

NS&T Alaska blue mussel data were queried for the eleven metals we sampled, for years from 1986-2013 (n=110), and 1995-2013 for southeast Alaskan only (n=20) levels. Hawk Inlet mussel data were converted to dry weight equivalents using 80% moisture content. For nine of the eleven metals (As, Cd, Cr, Cu, Pb, Ni, Se, Ag, Zn … *not* Mn or Hg), Hawk Inlet concentrations were slightly to substantially higher than both the southeast Alaska and statewide mussel watch program metal concentrations in blue mussel tissue. Based on NS&T mussel metal assessment of 214 sites nationwide, Hawk Inlet mussels are in or exceed the 85^{th} percentile for As, Cd, Cr, Pb and Ni, and high in the 50^{th} percentile for mercury. The 85^{th} percentile are considered "high concentrations which are thought to be subject to human control or are of biological significance" (O'Connor 2002).

When compared to historic data from Hawk Inlet, mussels provide the most consistent and long term data for comparison. Findings from the FOA 2015 reconnaissance sampling indicate that arsenic, chromium, copper, lead, nickel and selenium have increased in concentration in blue mussels by factors of 2x to at least 5x compared to the 1978/79 baseline, the 1981 baseline, and the 1984-1989 baseline concentrations reported in documents from early studies on Hawk Inlet. Cockle and clam data exhibit similar trends.

Historical scientific records document an abrupt increase in several trace metals in Hawk Inlet after the mine began industrial operations. The suite of metals in Hawk Inlet seafood species continues to reflect the composition of ore being extracted. Metal levels indicate that Hawk Inlet marine habitats are degraded compared to pristine Alaskan sites and relative to its pre-mining condition. Further analysis of pre-mining baseline data and replication of those studies is essential to evaluate trends in bioaccumulation of metals, interpret ecosystem status indices, and assess sustainability and health of edible seafood populations in Hawk Inlet.

This project note is intended to provide an update on results of study and analysis of selected marine species from Hawk Inlet in 2015. Some context is provided from other studies to aid in interpreting the level of trace metals found in seafood analyzed. No context is provided or implied pertaining to status of seafood in Hawk Inlet for human consumption.

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Table 1. Profile of Household Harvest and Use of Marine Invertebrates and Marine Algae in Angoon, Alaska
Data extracted from USFWS 1988, Table 3 and ADFG 2012

Invertebrate / Seaweed	% of Households Using		Estimated Harvest Amount	Species Occurs in Hawk Inlet
	1988	2014	2014	(Ridgway 2015)
Blue Mussels	5.3			YES
Basket Cockles	2.6	50.9	410	YES
Heart Cockles	60.5	60.7	1,423	YES
Clams (Butter, Horse, Littleneck, UK)	73.7	50.9	2,193	YES
Dungeness Crab	44.7	49	842.9	YES
King Crab	23.7	7.8	257	YES
Tanner Crab	18.4	5.8	139	YES
Red Gumboot	5.3	2	239	YES
Black Gumboot (Bidarki)	68.4	66	2,665	YES
Sea Urchin	2.6	1.9	0	YES
Limpet	2.6	0	0	YES
Octopus	23.7	7.8	109	YES
Sea Cucumber	2.6	0	0	YES
Shrimp	5.3	13.7	15.9	YES
Black Seaweed	50	62.7	400	YES
Sea Ribbons	2.6	7.8	14.6	YES
Bull Kelp (2012 seaweed/kelp)	2.6	64.7	1082	YES

Table 2. Subsistence Species Collected in Hawk Inlet for Trace Metal and Organics Analysis

English Common Name	Tlingit Name	Scientific Name	Habitat	Analyses
Black Seaweed	Lakusk	*Porphyra* sp.	Intertidal	Metals
Rock Seaweed	tuyeideedahah	*Fucus gardneri*	Intertidal	Metals, Petroleum
Sea Lettuce		*Ulva* sp.	Intertidal	--archived--
Blue Mussel	Yak	*Mytilus trossulus*	Intertidal	Metals
Cockle	yulooleit	*Clinocardium nuttalli*	Intertidal	Metals
Dungeness Crab	Saw	*Cancer magister*	Subtidal	Metals
Flounder	Dzuntee	Pleuronectidae	Subtidal	--archived--
Helmet Crab		*Telmessus* sp.	Subtidal	Metals
Butter Clam	gal	*Saxidomus giganteus*	Intertidal	Metals, Petroleum
Horse Clam	yeis	*Tresus* sp.	Intertidal	Metals, Petroleum
Sculpin	weix	Cottidae	Subtidal	--archived--
Sea Cucumber	yein	*Parastichopus*	Subtidal	--archived--
Side Stripe Shrimp	Seex ut	*Pandalus dispar*	Subtidal	Metals